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63-2-1

NEL REPORT 1133

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AN/UQC-1(XC 1)

A transistorized, modular, general utility sonar communications set using a new high-performance transducer and improved circuitry designed to replace the AN UQC-1 for operational Fleet service.

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Fred D. Parker • David A. Baldwin
DEVELOPMENT REPORT
U. S. Navy Electronics Laboratory
San Diego, California • 28 SEPTEMBER 1962
A BUREAU OF SHIPS LABORATORY

Design and build a general-purpose underwater communication set compatible with and capable of replacing the AN UQC-1 sonar on submarines and surface craft. The equipment is to equal or exceed the performance of the underwater communication set previously designed by NEL for the bathyscaph TRIESTE.

NEL designed, built, partially tested, and shipped the AN UQC-1(XG-1) general-purpose underwater communication set. This equipment meets the problem requirements and has the following advantages over the present standard AN UQC-1:

1. Improved efficiency and greater range resulting from a new transducer and associated circuitry.
2. Reduced weight, size, power consumption, and heat dissipation due to the substitution of transistors for vacuum tubes.
3. Simplified maintenance because of modular construction in the electronic cabinets.

1. Give the AN UQC-1(XG-1) an operational Fleet evaluation.
2. Draft specifications for a pilot order of the set from a commercial vendor.
3. Plan for both topside and bottomside transducers on submarines using the AN UQC-1(XG-1) sonar.

This work was done by the High Resolution Sonar and Technical Services Divisions of NEL under BuShips project S-F006 04 01, Task 8875 (NEL B2-5) between May 1961 and July 1962.

Personnel of the Electronic Equipment Section provided valuable help in completing this project.

This report was approved for publication on 28 September 1962.

PROBLEM

RESULTS

RECOMMENDATIONS

ADMINISTRATIVE INFORMATION

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BACKGROUND

The AN UQC-1(XG-1) is completely compatible with the present standard AN UQC-1. It is more efficient, weighs less, has greater range, consumes less power, and should be simpler to maintain than the standard set.

The underwater communication sets designed and built by NEL for the bathyscaph TRIESTE and its work boat functioned without fault during the record 35,800 ft descent into the Challenger Deep on 23 January 1960. The satisfactory performance of this system led BuShips in 1961 to request that NEL undertake the design of similar equipment especially adapted for use aboard deep-running submarines. The TRIESTE's underwater communication sets were the prototypes for the AN UQC-1(XG-1).

BuShips requirements for the design were: The new equipment must be able to equal or excel the performance of the TRIESTE set; it must be compatible with existing communication systems; it must be no larger than the AN UQC-1; and it must be operated from a remote control box which will fit into the space now occupied by the control set of the present standard equipment.

In July 1962 NEL sent the AN UQC-1(XG-1), which was designed and built at the Laboratory, to a shipyard for installation aboard a submarine. The set meets all the conditions set forth by BuShips. Bathyscaph personnel were so impressed with its performance that they requested a duplicate set for use on the TRIESTE work boat.

**TRIESTE equipment
prototype for
AN/UQC-1(XG-1)**

**All BUSHIPS require-
ments met**

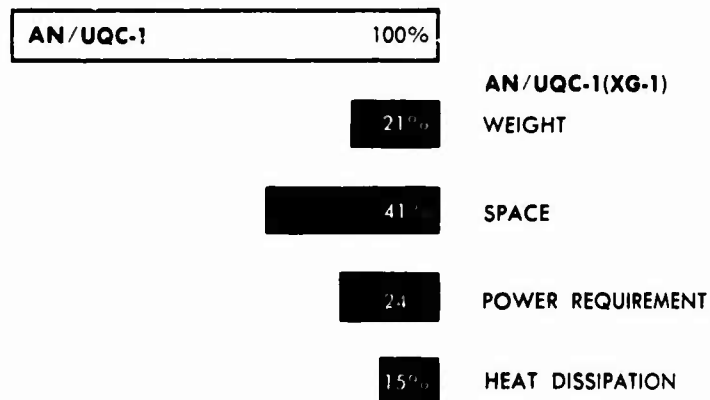
COMPARISON of the AN/UQC-1(XG-1) and the AN/UQC-1

Advantages in efficiency, size, power consumption

The AN/UQC-1(XG-1) appears to be more satisfactory than the present standard AN/UQC-1 because of an unusually efficient transducer, improved circuitry, and modular construction. The increase in transducer efficiency from about 15 to nearly 60 per cent is the reason the new set will put more acoustical energy (120 watts instead of 60 watts) into the water with less electrical energy (200 watts instead of 400 watts). Since range is related to acoustical power, the new set will communicate at greater ranges.

Substituting the new transducer for the AT 186A UQC-1 in the AN/UQC-1 would increase significantly that set's performance.

The use of transistors instead of vacuum tubes in the AN/UQC-1(XG-1) has reduced weight, size, power, and heat dissipation requirements. The modular construction permits rapid repair and minimizes down time.



	AN/UQC-1	AN/UQC-1(XG-1)
Volume	9.77 cu ft	2.04 cu ft
Weight	562 lb	232 lb
Slant range	12,000 yd	Over 12,000 yd
Primary power (117 v 60 c/s)		
Transmitting	1700 w	100 w
Receiving	Not known	75 w
Power to transducer	100 w	200 w
Power to water	60 w (acoustical)	120 w (acoustical)
Power to heat dissipation	800 w	120 w
Transducer type	Magnetostrictive	Piezoelectric ceramic
Carrier frequency	8.0875 kc/s	8.0875 kc/s
Major electronic units	Vacuum tubes	Transistors
Transmission modes (Single-sideband suppressed carrier)	Voice and 712 c/s cw	Voice and 800 c/s cw
Audio sensitivity at 9 kc/s	Not known	35 db below 1 microbar
Acoustic sound pressure	Not known	97 db above 1 microbar

NAVY INSTRUCTION BOOK FOR SONAR SET AN/UQC-1A NAVSHIPS 90-22, APRIL 1962

Transmitter-Receiver Chassis



Power Supply Chassis



Remote Control Unit



Transducer

The AN UQC-1(XG-1) sonar consists of three subassemblies: The two-drawer electronic cabinet, the remote control unit, and the transducer. The electronic cabinet may be moved through submarine hatches; the remote control unit occupies no more space than the Control Set of the AN UQC-1; and the transducer is mounted on a flange with a bolt circle that will fit the fairing and bolt holes now utilized to fasten the AT 186A UQC-1(Sonar Transducer) to the hulls of using vessels.



AN/UQC-1(XG-1) Remote Control Box installed aboard a submarine

CONSTRUCTION features of AN/UQC-1 (XG-1)

THE HIGH-EFFICIENCY TRANSDUCER

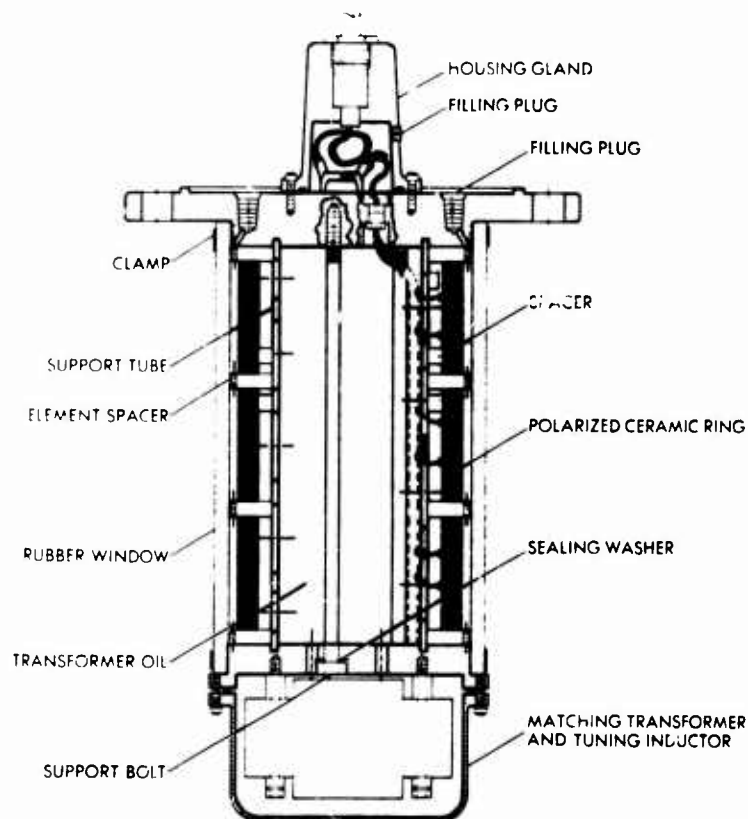
Piezoelectric ceramic transducer basis of improved efficiency

Piezoelectric ceramic transducers have important advantages in addition to their relatively high efficiency. Perhaps the most important is that they do not require the polarizing current which is necessary to energize the magnetostrictive cores of the present standard units.

During the preliminary design stage NEL learned that Bendix-Pacific had designed a piezoelectric ceramic transducer intended as a possible replacement for the AT/186A UQC-1, presently standard equipment for the AN UQC-1 Sonar Set.

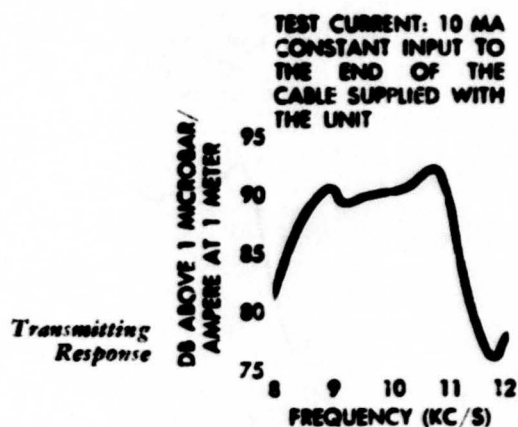
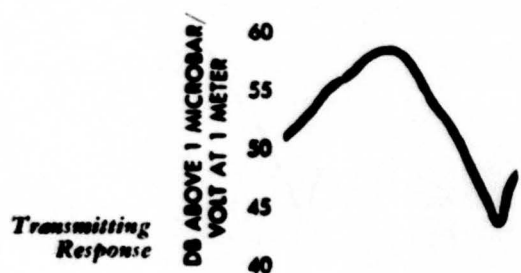
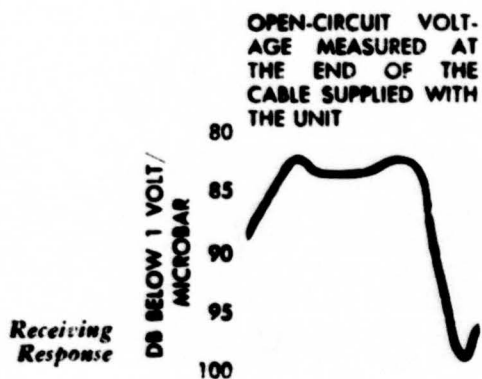
BuShips ordered the U. S. Navy Underwater Sound Reference Laboratory to test the instrument. Prior to its being shipped from the west coast to Orlando, Florida, NEL performed calibration tests at its Sweetwater Transducer Calibration Facility. These tests and those done at the Underwater Sound Reference Laboratory showed that the transducer's basic characteristics merited incorporating it into the new set.

The transducer consists of two major parts. The upper part contains barium titanate ceramic cylinders, and the lower part is a housing with a matching transformer. The matching transformer is placed at the transducer end of the DSS-3 cable so that the cable is actually a low-impedance line between the transducer and the cabinet. Holes in the plate between the two compartments permit oil to circulate freely through all interior parts.

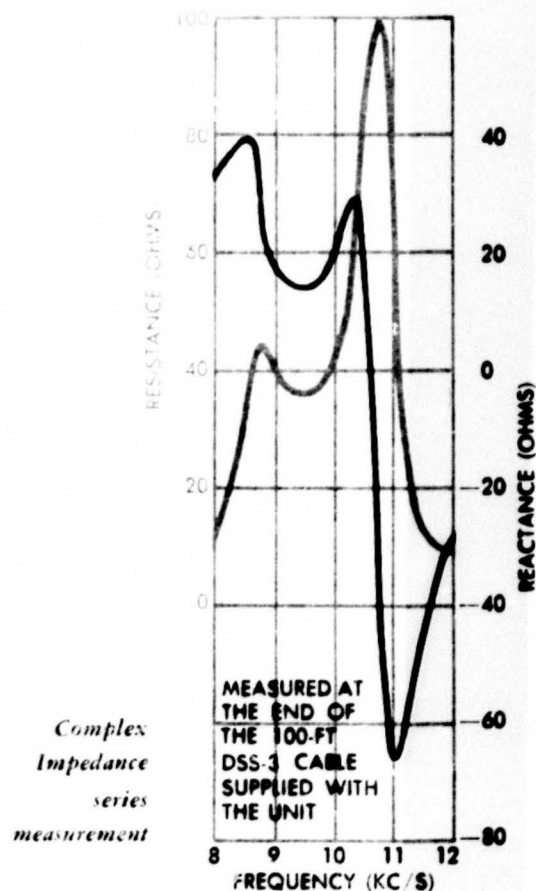


Cross Section of Transducer

The barium titanate cylinders are placed one above the other within an oil-filled rubber window. The manufacturer states that future production models will include the matching transformer within the rubber window rather than within a separate housing. The units are warranted to withstand pressures up to 10,000 psi. The manufacturer is reputed to have an improved cable gland which will allow the unit to withstand pressures of 20,000 psi.



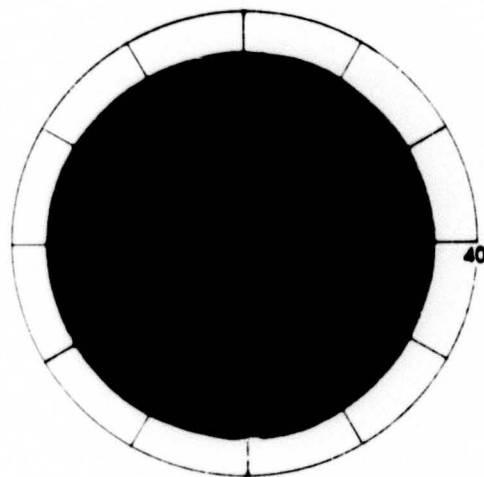
Calibration tests at NEL's Sweetwater Calibration Station of the transducer show high-level response. All measurements were made in the direction where $\theta = 90^\circ$. Similar tests at the Underwater Sound Reference Laboratory show that within the frequency range 8 to 10.5 kc/s pressures up to 1000 psi do not affect the transducer's response. A test consisting of cooling the unit to 5 C and then placing it in 25 C water showed no changes in sensitivity as the instrument warmed up.



Response and complex impedance tests of the AT 186A U.C.C-1, the present Fleet standard, comparable to those done on this transducer are not available.

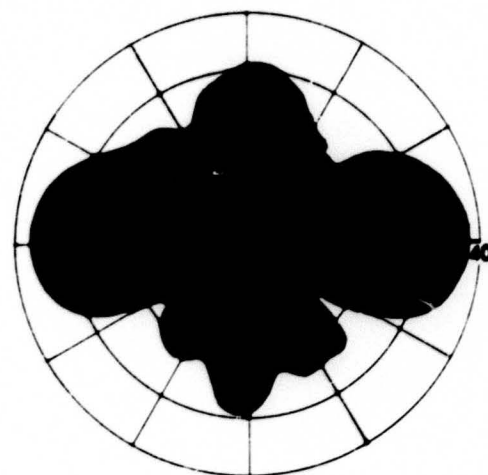
The NEL directivity tests indicate the transducer is omnidirectional in the horizontal plane at 8 kc/s. The Underwater Sound Reference Laboratory tests show it to be omnidirectional from 8 to 10.5 kc/s at 0 and 1000 psi.

Horizontal

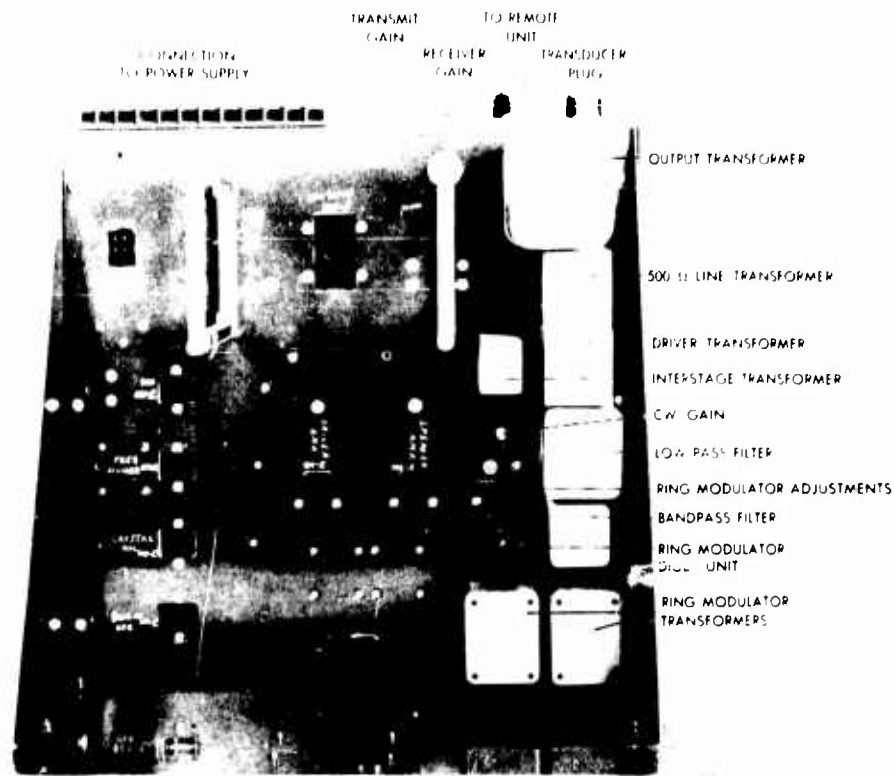


Tests in the vertical plane at 8 kc/s both at NEL and the Underwater Sound Reference Laboratory produce a lobed pattern as was expected. There is no significant difference between the patterns obtained at the two laboratories for the vertical plane. This includes Underwater Sound Reference Laboratory patterns obtained using driving power of 450 watts at 100, 500, and 1000 psi.

Vertical



CABLE END



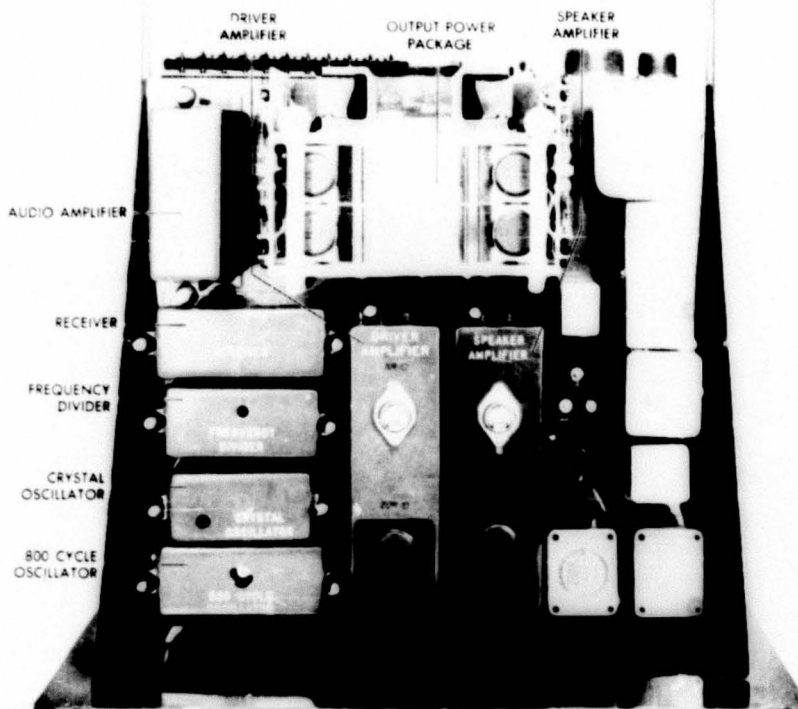
Transmitter-Receiver Chassis with MODULES REMOVED

USE OF MODULAR PLUG-IN UNITS

Plug-in units provide for easy maintenance

Except for a few transformers, filters, and potentiometers which are necessarily chassis mounted, the upper (transmitter-receiver) cabinet uses modular plug-in construction. One transformer in the lower (power) cabinet is also constructed in this fashion. These plug-in modules are securely fastened down, but can easily be removed for replacement with spare modules. Down time is thus materially reduced and the faulty modules are set aside for repair or adjustment at a later convenient time. The AN UQC-1(XG-1) was shipped with a complete set of spare modules.

Within each module components are arranged to conserve space and to be readily



Transmitter-Receiver Chassis with MODULES IN PLACE

accessible. All connections are made with wire rather than printed circuits. Each module is enclosed within a protective case. The volume requirements for this set were not critical and it is not as small as it would be if a greater effort had been made to conserve space and miniaturize components.

When the AN UQC-1(XG-1) is installed, the remote control box is permanently connected to ship's power. This makes possible instant operation when the ON-OFF switch is flipped. The box is located at the ship's control center; the electronic cabinets are installed at any convenient place where accessibility for maintenance is available.

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of individual components*

Receiver



Audio Amplifier

*Frequency
Divider*

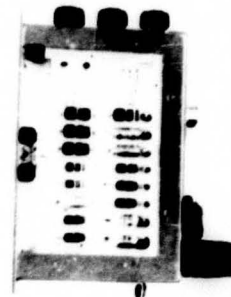
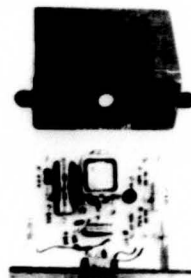


Output Power Package

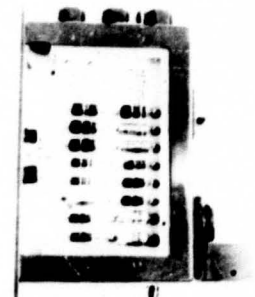
*Crystal
Oscillator*



*800 Cycle
Oscillator*



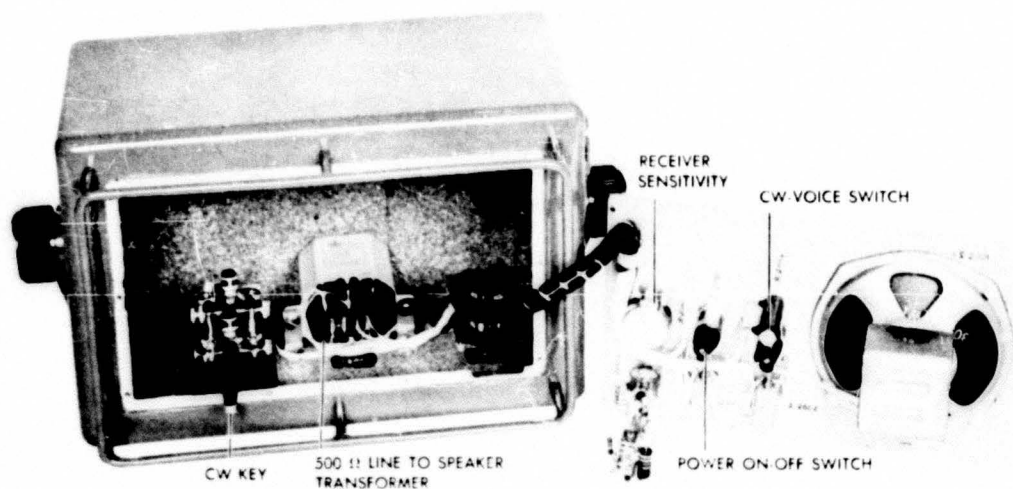
Driver Amplifier



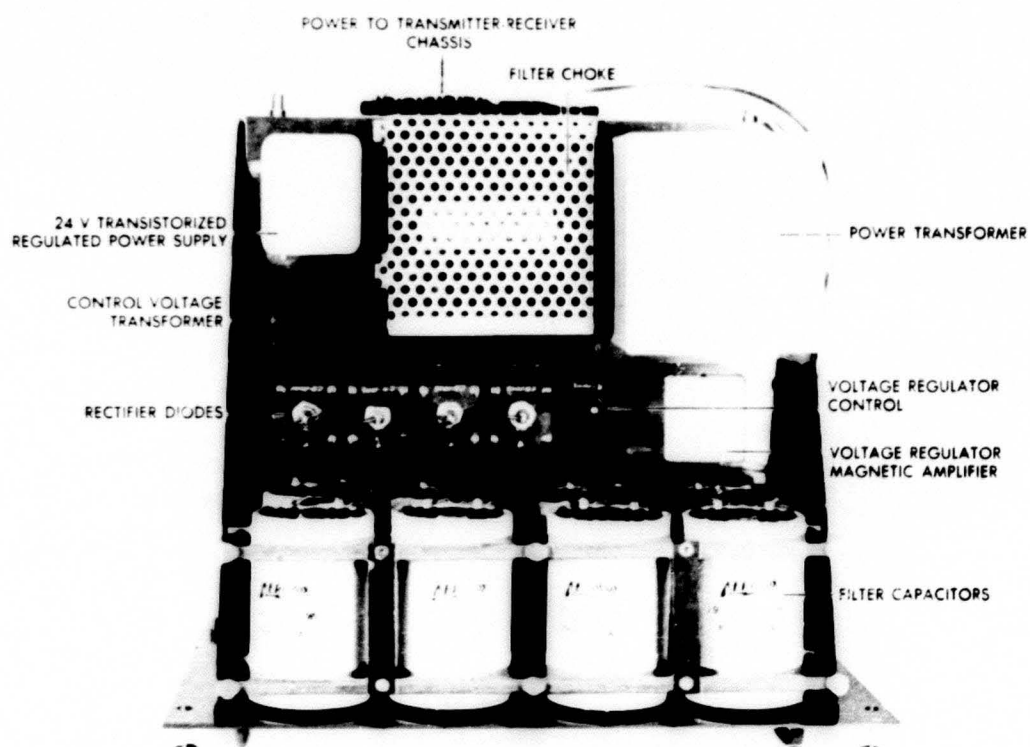
Speaker Amplifier

interchangeable

*fold out page for photographs
of individual components*



Remote Control Box with panel removed



Power Chassis

OPERATION of the AN/UQC-1 (XG-1)

PROCEDURES

Operation like that of standard AN/UQC-1

The operation of the AN UQC-1(XG-1) is similar to that of the AN UQC-1. The principal difference is that instead of waiting for the vacuum tubes to warm up as when using the standard set, the AN UQC-1(XG-1) is ready to transmit or receive as soon as it is turned on and the "MAIN POWER" light glows. The transistor elements require no warm-up period.

All the operator controls are on the remote control box. After flipping the on-off switch to the "ON" position, the operator is ready to transmit by pressing the push-to-talk button on the side of the microphone. When the transmitter is working properly, the "TRANSMIT" light will flicker intermittently during voice transmission. Releasing the push-to-talk button places the equipment in the receive position.

To send cw signals the toggle switch is flipped to the "CW" position and the key is used in place of the microphone. Releasing the key returns the set to the receive position.

Placing the earphone jack into the receptacle marked "PHONE" disconnects the speaker in the remote control box. The dial "REC. SENS." controls both phone and speaker gain.

Should one of the transistors in the power amplifier fail, a light corresponding to the faulty unit will glow on the front panel of the upper electronic cabinet. When this occurs, the power amplifier module is removed and a spare module inserted. When time permits, the appropriate transistor is replaced.

PRINCIPLES

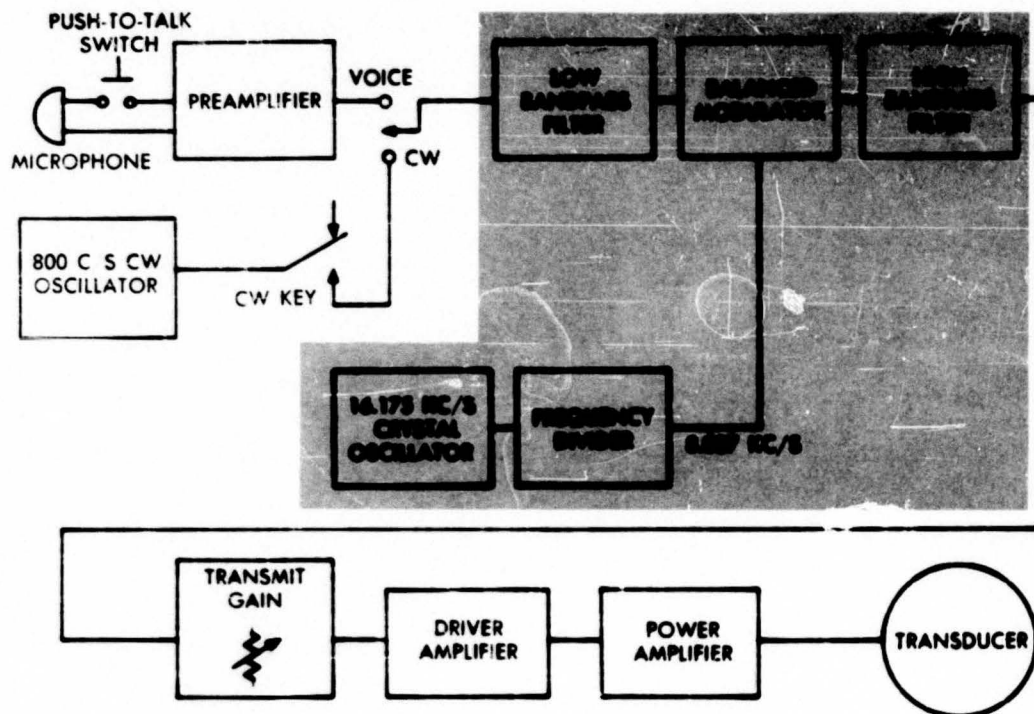
The AN UQC-1 (XG-1), like the present Fleet underwater telephones, uses a single-sideband suppressed-carrier wave of 8.0875 kc/s. When the unit is transmitting, the microphone converts audio signals within the range 300 to 3000 c/s to electrical signals. After passing through the preamplifier, these signals (or cw pulses from the 800 c/s oscillator) go to a low-pass filter. The output is then fed to a balanced modulator and mixed with the carrier.

Uses 8.0875 kc/s single-sideband suppressed carrier

Since the circuit uses a balanced modulator, the resulting output includes an upper sideband that is the sum of the carrier wave and the audio wave, and a lower sideband which is the difference between these two waves. The lower sideband is filtered out with a bandpass filter leaving an upper-sideband, suppressed-carrier wave. After amplification this signal drives the transducer, thus converting electrical energy into sound energy.

When the set is receiving, sound energy reaching the transducer is converted to electrical energy that is amplified and fed to a bandpass filter. This signal is demodulated by being mixed with the 8.0875 kc/s carrier wave. The output from the balanced modulator includes the sum of the carrier wave and the received signal waves as well as the difference between the two waves. High-frequency components are filtered out by a low-pass filter leaving the audio wave which, after passing through the speaker amplifier, is fed to the speaker or the earphones.

The AN UQC-1(XG-1) microphone is a differential dynamic unit with high noise



Transmit

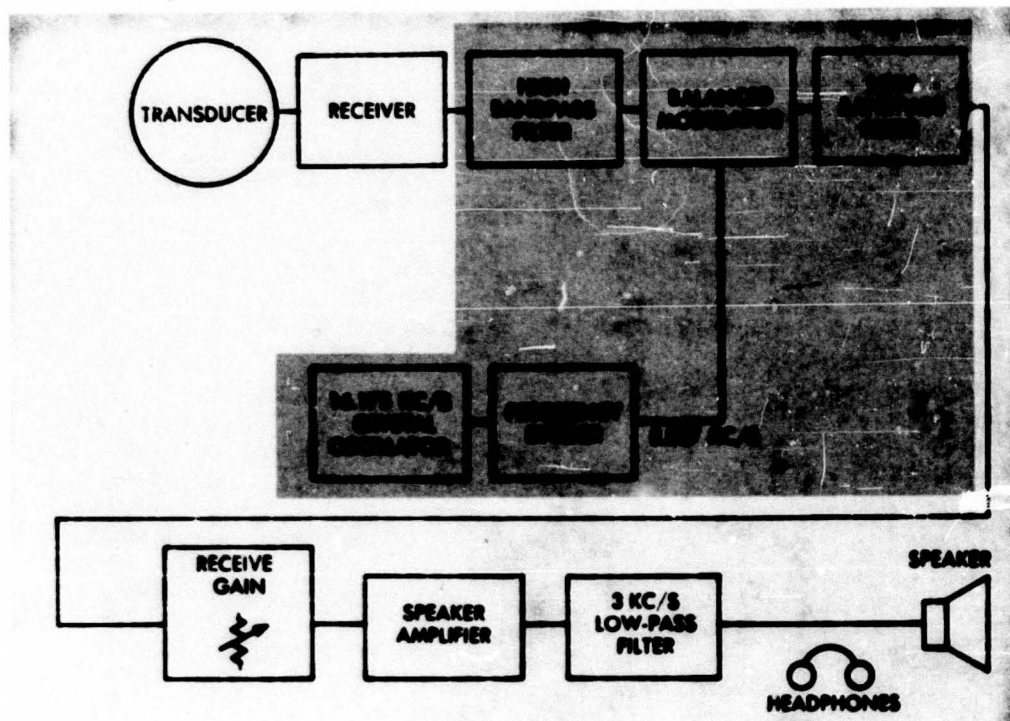
cancellation and high articulation qualities. Signals from the microphone go to the three-stage preamplifier, which has a common emitter, common collector configuration. Three resistors and a by-pass capacitor provide base stabilization, and a feedback network establishes gain stability.

A low-pass filter is used to remove all signal components over 3000 c/s. The signal then enters the balanced modulator where it is mixed with the 8.0875 kc/s carrier wave. This carrier is generated by a 16.175 kc/s crystal oscillator whose output passes through a frequency divider.* After going

through the high bandpass filter, which takes out the lower sideband, the signal, now consisting of an upper sideband suppressed-carrier wave, goes through the driver and power amplifiers to the transducer.

When the transmitter is in the cw (keying) position, the preamplifier is disconnected and an 800 c/s crystal oscillator is placed in circuit. Pressing the telegraph key starts a signal from the oscillator to the low-pass filter. The remainder of the circuitry operates just as it does when voice signals are transmitted.

*The recent availability of suitable 8.0875 kc/s crystals would make the divider circuit unnecessary in a production model.

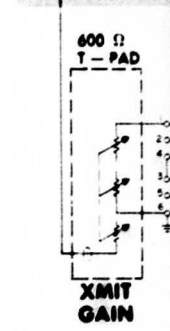
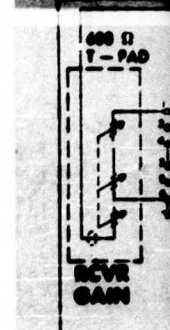
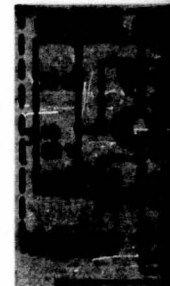


Receive

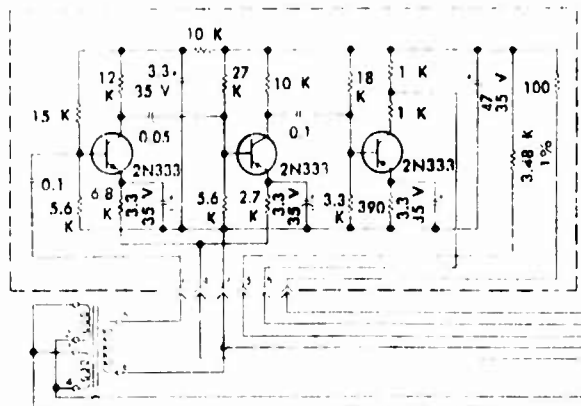
During reception, the electrical impulses which the piezoelectric ceramic transducer generates are amplified in the receiver and sent to the high bandpass (8.5 to 11.5 kc/s) filter. In the balanced modulator the amplified signal is mixed with the 8.0875 kc/s carrier wave. This results in an upper sideband signal containing the sum of the signal and the carrier wave, and the lower sideband made up of the difference between the carrier and the received signal. The 3000 c/s low-pass filter removes the high-frequency components, leaving an audio wave. This wave, after being amplified and filtered, drives the speaker or head phones.

1

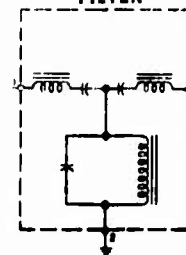
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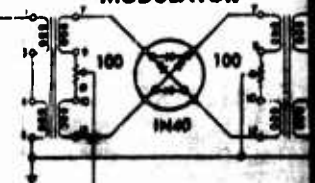
RECEIVER MODULE



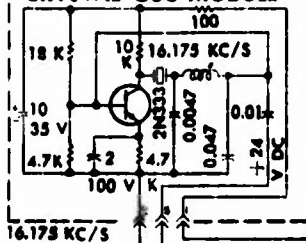
HIGH BANDPASS FILTER



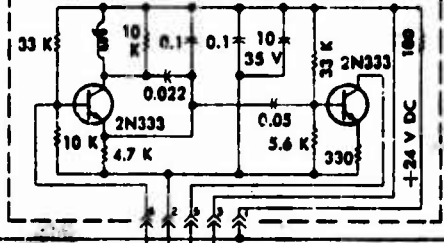
BALANCED MODULATOR



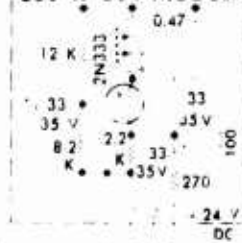
CRYSTAL OSC MODULE



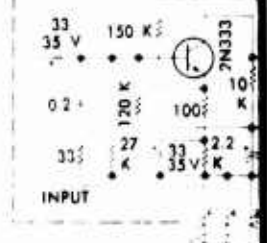
FREQUENCY DIVIDER MODULE



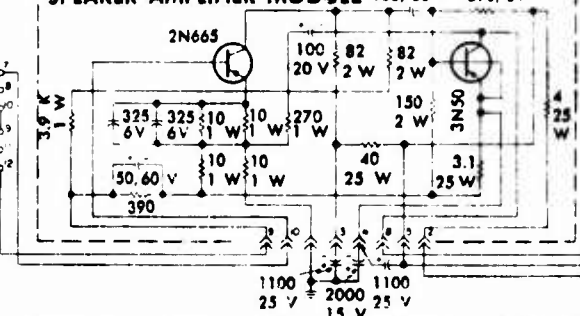
800 Hz OSC MODULE



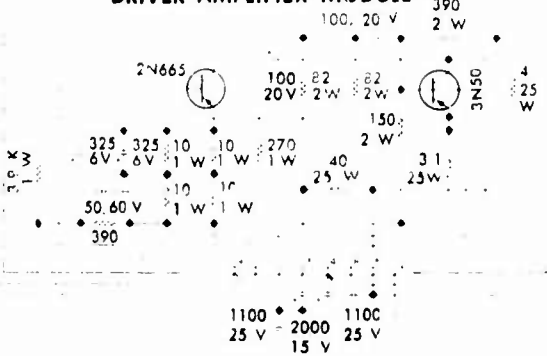
AUDIO A



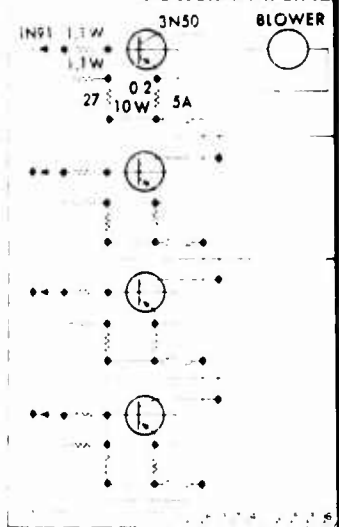
SPEAKER AMPLIFIER MODULE



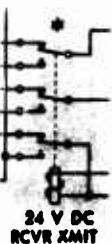
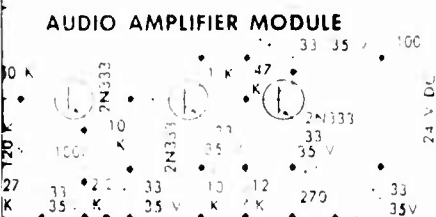
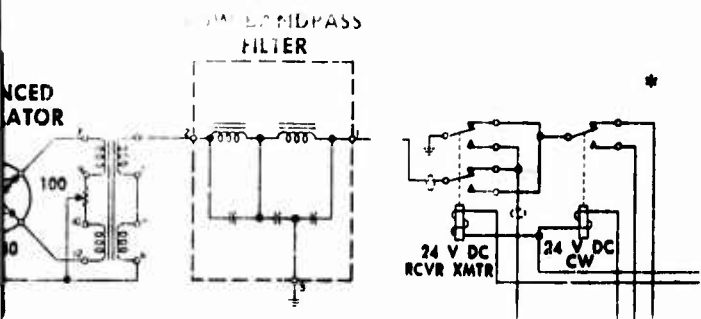
DRIVER AMPLIFIER MODULE



POWER AMPLIFIER



POWER TRANSISTOR FAILURE INDICATOR



18 115
J902

TO TRANSFER

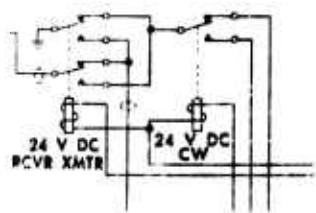
BARRIER STRIP

- 24 V NEUTRAL TO AMPS
- 24 V AT 20 AMPS
- CHASSIS GND
- 24 V NEUTRAL TO TRANS
- 24 V TRANS
- ON/OFF RELAY MOUNT
- 5.8 V FOR IND LT
- 5.8 V FOR IND LT
- 117 V AC

UNLESS OTHERWISE SPECIFIED:
RESISTANCE IS IN OHMS
CAPACITANCE IS IN MICROFARADS
INDUCTANCE IS IN HENRIES
RESISTORS ARE IN WATTS
CAPACITORS ARE IN WV
TOLERANCE IS IN %

CAUTION: Do not attempt any testing, w
plied, without transducer or
connected to J902. Before p
applied to equipment, a ju
connected between pins B & (

* RELAYS SHOWN IN UNENERGIZED PO



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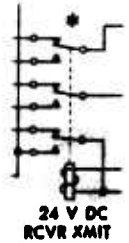


100

24 V DC

33

35V



18 115



TO TRANSFER

BAR P

STRIP

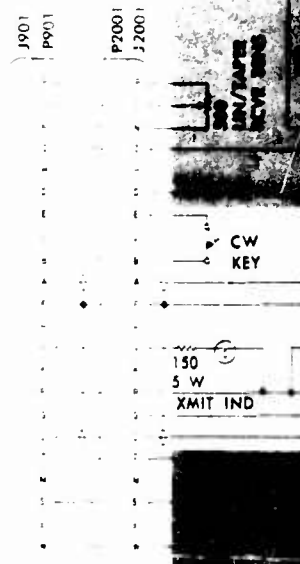
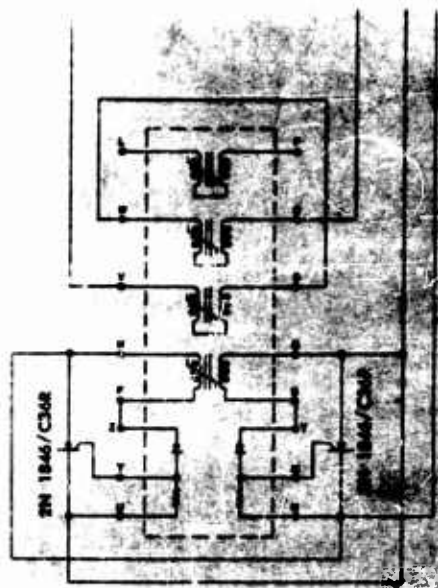
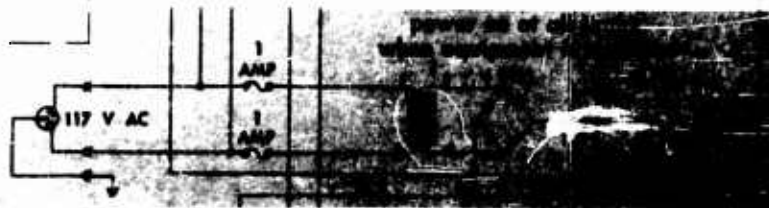
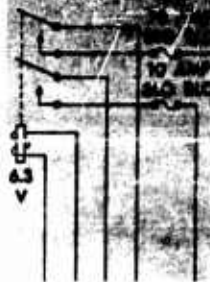
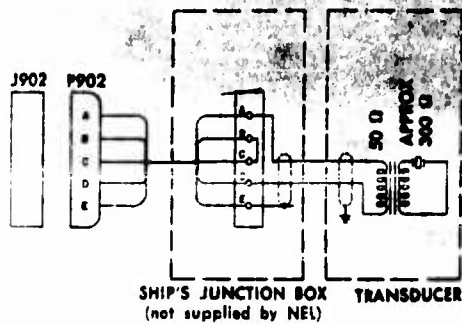
- 24 V NET AT 10 AMPS
- 24 V AT 10 AMPS
- MASSIVE TRID
- 24 V NET TRANSFER
- 24 V TRANSFER
- ON/OFF RELAY CONTROL
- 5.8 V FOR IND. LT
- 5.8 V FOR IND. LT
- 117 V A

UNLESS OTHERWISE SPECIFIED
RESISTANCE IS IN OHMS
CAPACITANCE IS IN MICROFARADS
INDUCTANCE IS IN HENRIES
RELAY COILS ARE IN WATTS
CAPACITORS ARE IN WATTS
TOLERANCE IS IN %

CAUTION: Do not attempt any testing, with power applied, without transducer or dummy load connected to J902. Before power can be applied to equipment, a jumper must be connected between pins B & C on J902.

* RELAYS SHOWN IN UNENERGIZED POSITION

OPTIONAL TRANSDUCER CIRCUIT FOR SHIP'S INSTALLATION



1

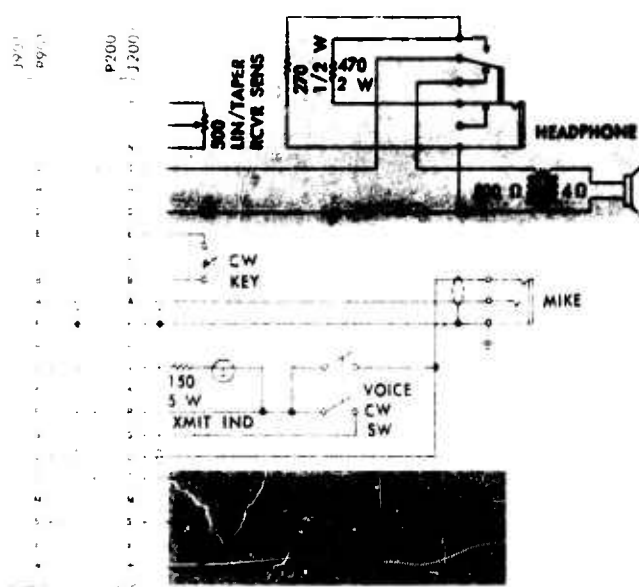


BARRIER STRIP

- 24 V DC 20 A
- 24 V DC 20 A
- CHASSIS GND
- 24 V DC TRANSPAC
- 24 V DC TRANSPAC
- POWER RELAY CONTROL
- 5 B V DC IND LIGHT
- 5 B V DC IND LIGHT
- 117 V AC



REMOTE CONTROL UNIT



TRANSFORMER

UNLESS OTHERWISE SPECIFIED
RESISTANCE IS IN OHMS
CAPACITANCE IS IN MICROFARADS
INDUCTANCE IS IN HENRIES
RESISTORS ARE IN WATTS
CAPACITORS ARE IN WV
TOLERANCE IS IN %

CAUTION. Do not attempt any testing, with power applied, without transducer or dummy load connected to J902. Before power can be applied to equipment, a jumper must be connected between pins B & C on J902.

Sonar Set, Power Supply and Remote Control Unit

The power supply for the **AN UQC-1 (XG-1)** is conventional for transistorized circuitry. Regulation for the controlled portions of the power supply is within 1 per cent.

RECOMMENDATIONS

Preliminary tests successful

FLEET EVALUATION

This experimental sonar set has been tested as extensively as production deadlines would permit. Since it was modeled after a communication set used successfully on the TRIESTE, NEL is confident that the AN/UQC-1 (XG-1) will meet BuShips requirements for performance and reliability.

The completed set was carefully bench-tested prior to a dock-side test at NEL and was operationally tested with the TRIESTE during a practice dive which took the bathyscaph to a depth of approximately 3700 ft.

During the operational test with the TRIESTE, the AN UQC-1(XG-1) was installed on the work boat and used for auxiliary communication with the bathyscaph, which used the NEL designed equipment that had served as a prototype for the AN UQC-1 (XG-1). The noise level in the water at the time of this test was high, but the experimental gear maintained continuous communication with the bathyscaph.

Fleet tests needed

One of the characteristics yet to be determined is the effective range. Because this range is a function of many factors — local noises, thermoclines, vessel's speed, methods of mounting — it would not be possible to rate the set accurately without a relatively long service test under a wide variety of conditions. If and when there are two sets built to the same specifications, it will be possible to obtain much more reliable information than that which could be obtained from a single-set test program.

While the transistors used in this set have been tested at power values considerably over their rated values, their performance over long periods and under emergency conditions is not known. The actual life expectancy of transistors can be determined only through actual service use. However, they are expected to last longer than vacuum tubes.

PRODUCTION CONSIDERATIONS

The AN UQC-1(XG-1) was designed for convenience in construction as well as in operation. No exotic components were used; all parts are "off-the-shelf" or easily fabricated items. It is probable that well-qualified manufacturers could make at least minor improvements in the design and building procedures. Several manufacturers are capable of producing this underwater communication set.

**Designed for construction
convenience**

New electronic components and new forms of old components appear almost daily. When the specifications for a pilot order of the AN UQC-1(XG-1) are written, they should be flexible enough so that the vendor may use new components which will perform as well or better than those used in the original design. For example, since the experimental set was built, a new 9000 microfarad capacitor made in a flat shape has appeared. Using this capacitor in place of the round ones employed would reduce the space requirements of the power chassis. The present availability of an 8.0875 kc/s crystal oscillator is another case in point.

Topside and bottomside transducers desirable

TOPSIDE AND BOTTOMSIDE TRANSDUCERS

In submarine installations the transducers for underwater communication sets are usually placed on the bottom of the hull in order that the vessel may communicate when surfaced. However, hull interference from this position is significant when the submarine is communicating with a vessel at a lesser depth. Installing transducers both bottomside and topside increases the efficiency and range of submarine communications. The sonar operator is then able to use whichever unit produces the best results.

SUMMARY OF RECOMMENDATIONS

1. Give the AN/UQC-1 (XG-1) an operational Fleet evaluation as soon as possible.
2. Draft specifications for the AN/UQC-1 (XG-1) and award a contract for a pilot number of sets to a commercial vendor. Allow the manufacturer to substitute newly available components if they are superior to those used in the experimental design.
3. Install both topside and bottomside transducers on submarines using the AN/UQC-1 (XG-1).

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Navy Electronics Laboratory, Report 1139
UNDERWATER COMMUNICATIONS SET AN UQC 1 RG 1, by
F. D. Parker and D. A. Baldwin, 26 p., 28 September 1962.
UNCLASSIFIED

The AN UQC 1 RG 1, general purpose underwater communications set was developed based on NEL designed equipment of this type used with the bathyscaph TRIESTE. The AN UQC 1 RG 1 is compatible with and capable of replacing the present standard AN UQC 1 sonar. It offers the following advantages over the AN UQC 1: improved efficiency; greater range; reduced weight, size, and power consumption; and simplified maintenance.

1. Model AN UQC 1 RG 1
2. Underwater communication systems
- I. Parker, F. D.
- II. Baldwin, D. A.

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